



# **Government DPM Marking Development Programs**

**Status As Of May 2004**



# AIT Background Information



# What is Automatic Identification Technology (AIT)?

AIT enables the electronic tracking and control of parts and products hardware from cradle to grave. A typical AIT system consists of the following basic elements:

- Marking or printing device
- Mark quality verification system
- Reader/data capture device
- Data transmission means
- Computer database and related application programs



## AIT Begins With the Marking of the Product

- UID is the foundation of traceability - it is the link that allows us to relate parts and products to their design, manufacturing, and operational histories
- Machine readable codes provide a means to electronically exchange information between operators and the host computer(s).
- Automated data exchange is the key element in paperless systems.
- AIT system development activities have been hindered by marking challenges.



# The Automation Problem!

## **Traditional Linear Bar Codes Do Not Fulfill The UID Needs Of the Department of Defense**

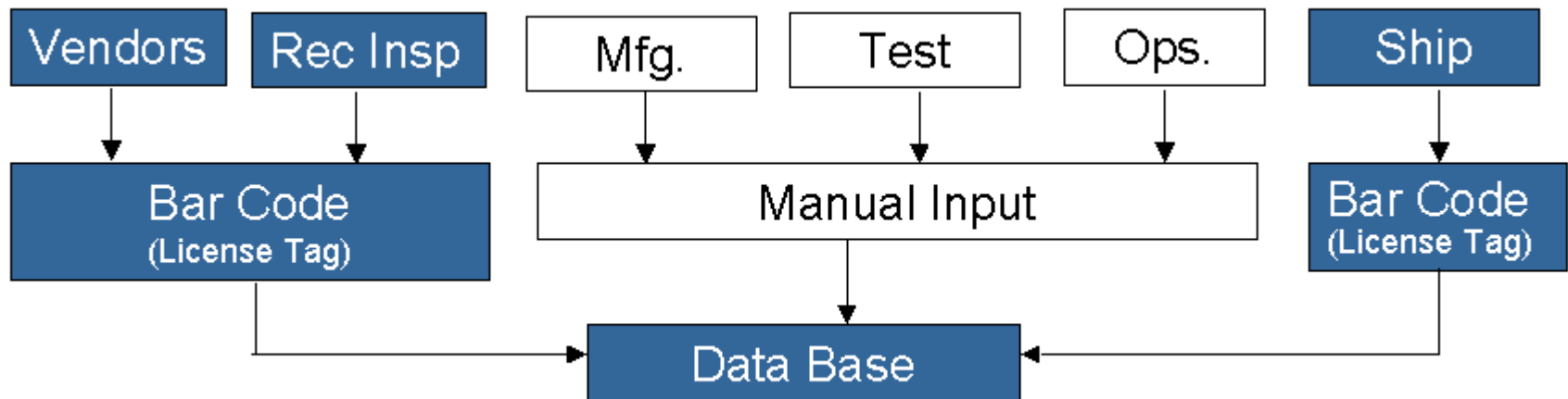
- Designed for retail industry
- Use limited due to large code size
- Cannot be read omni-directionally with typical laser scanners
- Cannot be normally read off non-label substrates
- Will not withstand harsh operational or environmental damage



## Uses of Linear Bar Code

### Examples:

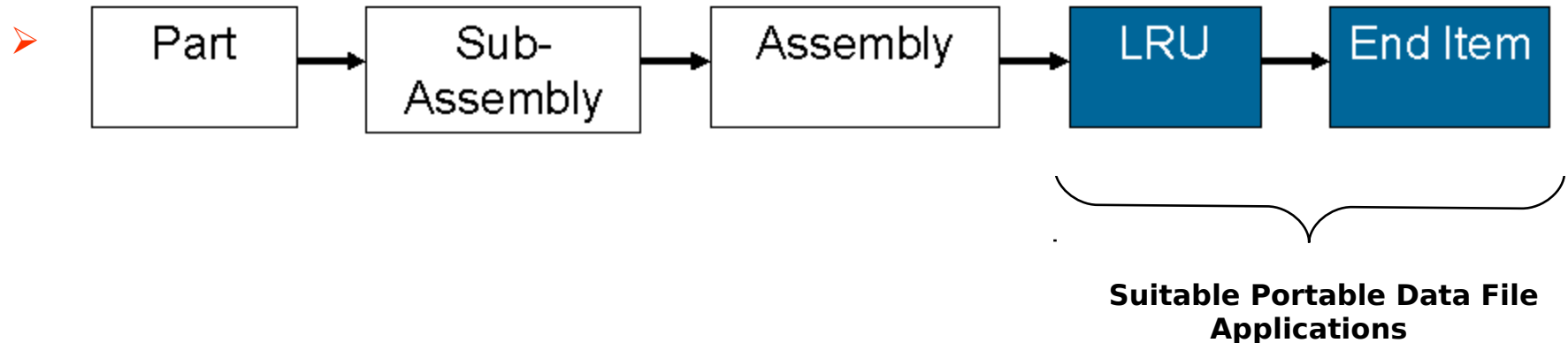
- Track packaged parts and boxes electronically
- Use normally limited to paper-based logistics operations (labels & tags)





## How are Memory Buttons, RF ID, and Smart Cards Used?

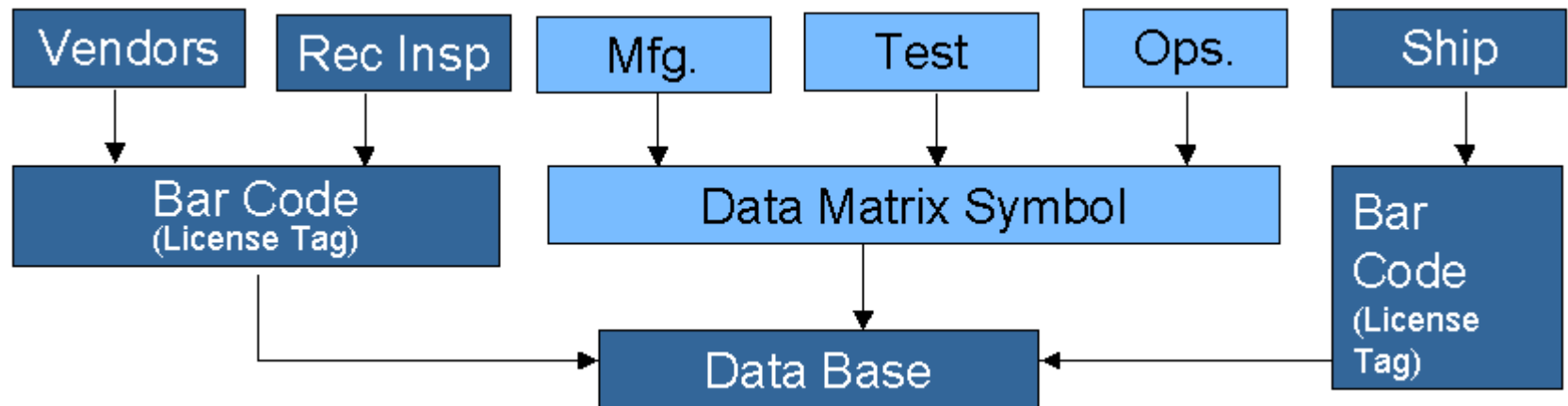
- Adopted to store information related to installed or packaged parts (portable data files)
- Used in applications where central database can not be easily accessed
- Designed for use with larger items and in friendly environments





## What Is Needed?

A technology adopted to meet operational logistic requirements and to extend UID into and field operations (direct part marking - DPM)







## Data Matrix Is Now The Standard For DPM

- Data Matrix is in public domain
- Approved as an American Standard by ANSI/AIM BC11-1997
- Approved as an International Standard by ISO 16022-July 2000
- The following industry organizations have adopted Data Matrix:
  - Air Transportation Association (ATA) – Spec 2000 (New ISO 21849)
  - Automotive Industry Action Group (AIAG) – B-4
  - Electronics Industries Association (EIA) – component marking standards
  - Health Industry Business & Communications Council (HIBCC) - pending
  - International Aerospace Quality Group (IAQC) – AS9132/EC9132/JCN9132 pending
  - National Aeronautics and Space Administration (NASA) - NASA-STD-6003 & NASA-HDBK-6004
  - Department of Defense - MIL-STD-130
  - Semiconductor Equipment and Materials International (SEMI) – wafer, glass panel and lead-frame marking
  - United States Postal Service (USPS) – postage metering



# **Government Data Matrix DPM Development Programs**



# Major Government Data Matrix DPM Development Programs

1	Develop New Symbol	NASA 2-D Symbol Selection and Development Program
2	Label Flight Tests	USCG Phase 1 – Label Flight Test Program
3	How-to-Instructions	NASA DMx DPM Standard and Handbook
4	Overhaul Test	USAF Aging Landing Gear Life Extension Program
5	LEO Tests Experiment	NASA Material - International Space Station – (Low Earth Orbit)
6	Post Delivery Marking	NCMS – Retrofit Part Marking Program (in-work)
7	DPM Flight Tests	USCG Phase II - DPM Flight Test Program (in-work)



# NASA 2-D Symbol Selection and Development Program

- Demonstrated that Bar Codes cannot be applied to parts using direct part marking methods (DPM).
- Evaluated 8 different 2-D symbols - Down selected to Data Matrix.
- Tested Encode/Decode software for accuracy.
- Developed new marking methods/techniques.
- Conducted tests on markings to determine affects on material properties.
- Marked Space Shuttle Orbiter flight hardware used in adverse environments.
- Developed new optical readers.
- Integrated hardware into paperless system - demonstrated to NASA leadership.
- Formed alliance with RVSI to further develop and commercialize 2-D symbols.





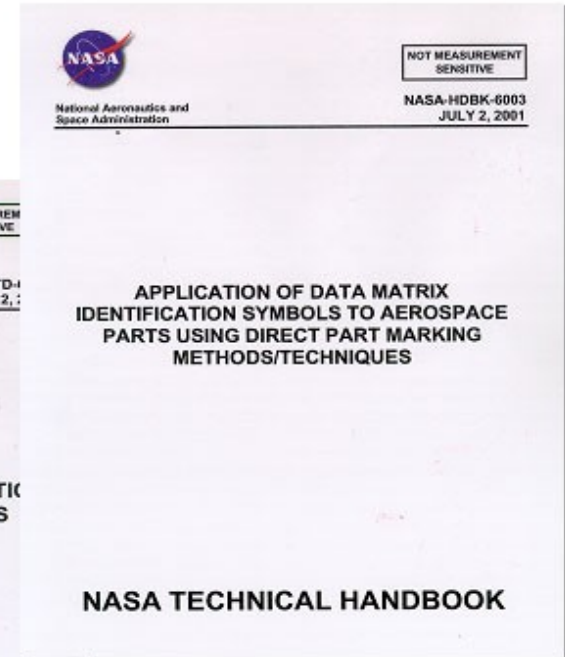
**Marked tiles on the shuttle's exterior endure 18,000 m.p.h slip stream during re-entry and temperatures that reach 2,300 degrees Fahrenheit.**



# NASA DMx DPM Standard and Handbook

How-to instructions  
on how to safely  
apply Data Matrix  
symbols to  
aerospace parts

***Documents  
developed by a 26  
member consortium  
including all  
branches of the  
armed services,  
DOT, FAA, NSTP,  
government labs,  
aircraft  
manufacturers, the  
major marking  
companies, and  
academia***





# USAF Aging Landing Gear Life Extension Program

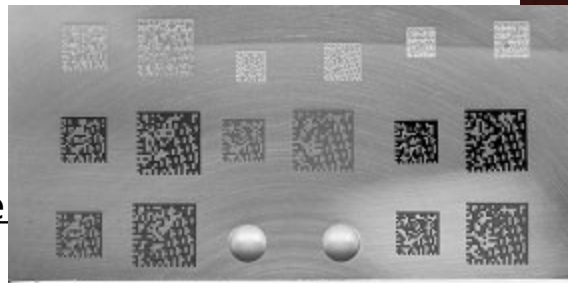
## FIGHTERS & BOMBERS

Marking effort focused on:

Uninstalled landing gear components

- Struts
- Wheels
- Brakes
- Mechanical Components

***Existing marking methods tested to determine how well they hold up to overhaul processes***

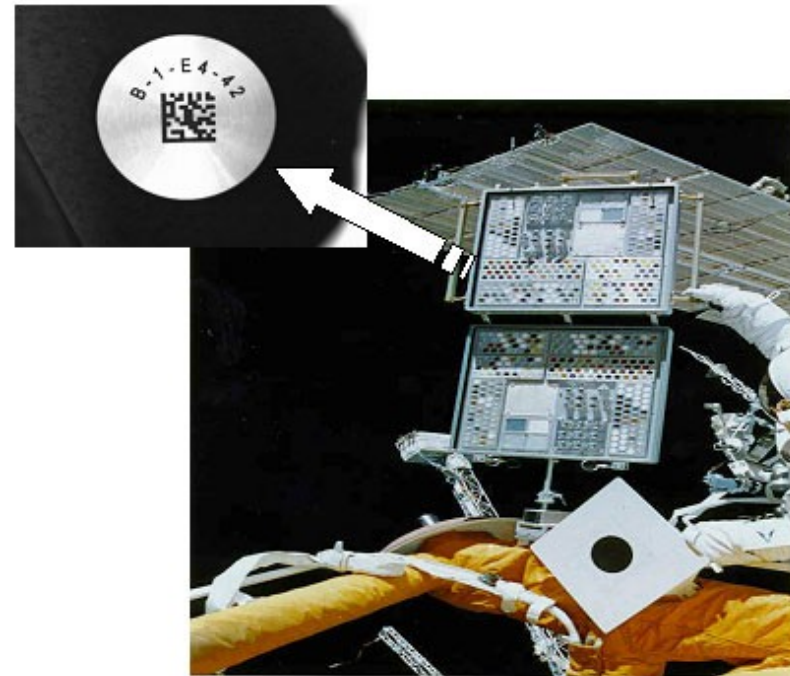
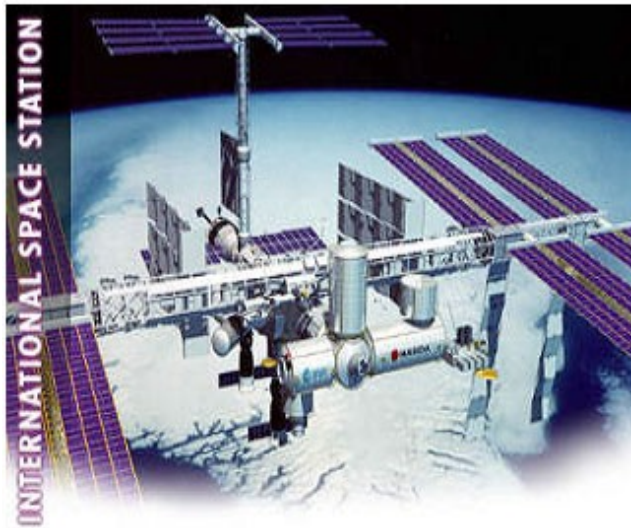






## M-ISS-E

Twelve different marking types being subjected to low earth orbit environments



***Existing markings being tested for use in reusable spacecraft - Experiment to be retrieved in summer of 2004***





# USCG ARSC Phase I & II Marking Program Overview

## HH60J Jayhawk - Medium Range Recovery Helicopter & C-130J Hercules Transport

Marking effort will focus on selected safety critical parts:

Both In-place (Installed) and removed components

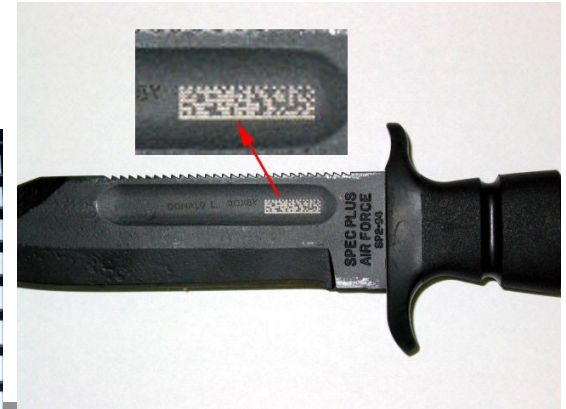
- Painted fuselage, structural, and mechanical components.
- Selected exterior engine components, including rotors, gears, etc.

***Existing and new markings were certified for flight - Marking completed and aircraft being flown***





## Other Government Marking Project





## Challenges Identified in Pervious Government Projects

- Symbol degradation in harsh operational environments
- Symbol degradation in rigorous overhaul processes
- Markings covered by protective coatings and paints
- Marking systems not available to mark in the field (post delivery hardware)
- Marking restoration processes/materials not available in field



# **DoD/NCMS Data Matrix DPM Development Program**



## Primary DoD/NCMS Program Objectives (SOW)

- Develop robust marking methods that will survive harsh operational conditions and overhaul processes (during and after manufacturer).
- Design, manufacture, test, and commercialize a family of portable part identification marking devices designed to mark parts in the field (both installed and uninstalled).
- Develop mark restoration kits and procedures
- Develop portable reading devices that can be used to image and decode symbols that have been discolored, contaminated, or coated over with protective coatings and paints.





# Government Participants And Observers

## The DoD (Lead Agency) &

- Defense Logistics Agency
- Department of Transportation
- Federal Aviation Administration
- National Aeronautics & Space Administration
- National Transportation Safety Board
- United States Army
- United States Air Force
- United States Coast Guard
- United States Marine Corps
- United States Navy





## Primary DoD/NCMS Program Tasks

1. Travel to multiple DoD sites to discuss part tracking problems
  2. Identify environments that degrade part Identification markings
  3. Enhance existing or develop new marking processes for use in harsh environments
  4. Test new processes to determine adverse affects on material properties
  5. Subject approved marking processes to DoD environmental tests
  6. Develop and test mobile markers
  7. Develop and test mark enhancement kits
  8. Test read-through-paint (RTP) readers
-



## **Task 1 - Travel to multiple DoD sites to discuss marking problems – Completed**

### **Sites Visited**

- US Air Force Materiel Command, Hill Air Force Base, UT
- US Army Anniston Depot, AL
- US Army Corpus Christi Army Depot, TX
- US Coast Guard Aircraft Repair & Supply Center, Elizabeth City, NC
- US Marine Corp Air Station, Cherry Point, NC
- US Navy Naval Air Station, Patuxent River, MD





## **Task 2- Identify Environments That Degrade Part Identification Markings - Completed**

### **Typical Operational Environments:**

- Abrasion
- Salt Spray
- Chemical Exposure: Hydraulic Fluid, Fuel, Grease, Cleaners, Deicers, etc.
- Temperature: -30F to +140F, engines up to 2000F
- Ultra-Violet Light
- Foreign Object Damage (Minor)



## Task 3 - New Marking Processes Evaluated

### - Complete

- Investment Casting
- Sand Casting
- Forging - Still under development
- Deep Dot Peen
- Deep Electro-Chemical Etch
- Gas Assisted Laser Etch (GALE)
- Laser Engineered Net Shaping (LENS) - Still under development
- Laser Induced Surface Improvement (LISI)
- Deep Laser Engraving
- Micro-milling
- M3D (Laser Bonding using aerosol jetting)
- Stencil - Thermal Spray (HVOF, Arc, and Flame Spray)



## **Task 4 - Test New Marking Processes To Determine Adverse Affects On Material Properties**

**- 95% Completed**

New marking processes are being subjected to testing to evaluate the effects that the marks have on material properties.

- Metallurgical Testing
  - Microscopy Evaluation
  - Geometric Characterization of Marks (Cell Height, Cell Depth)
  - Material Property Characterization of Marks
  - Chemical Etching Methods
  - Micro hardness Methods
- Corrosion Testing
- Fatigue Testing



## Task 5 - Subject Approved Marking Processes To DoD Overhaul Processes - **65%** **Completed**

### Blasting Processes

- Abrasive Blast per MIL-STD-1504, Abrasive Media (Plastic Media) per MIL-P-85891
- Abrasive Blast per MIL-STD-1504, Abrasive Media (Glass Media) Per MIL-G-9954
- Abrasive Blast per MIL-STD-1504, Abrasive Media (Garnet Media) Per MIL-A-21380
- Abrasive Blast per MIL-STD-1504. Abrasive media (Aluminum Oxide)
- Abrasive Blast per MIL-STD-1504, Abrasive Media (Grit Media) Per MIL-G-5634
- Abrasive Blast. Mask Marks
- Abrasive Blast. Do Not Mask Marks
- Shot Peen per AMS-S-13165, Intensity 0.006A to 0.010A, Shot S-230 to S-330
- Shot Peen. Mask Marks
- Shot Peen. Do Not Mask Marks



## Inspection, Stripping, Coating and Plating Processes

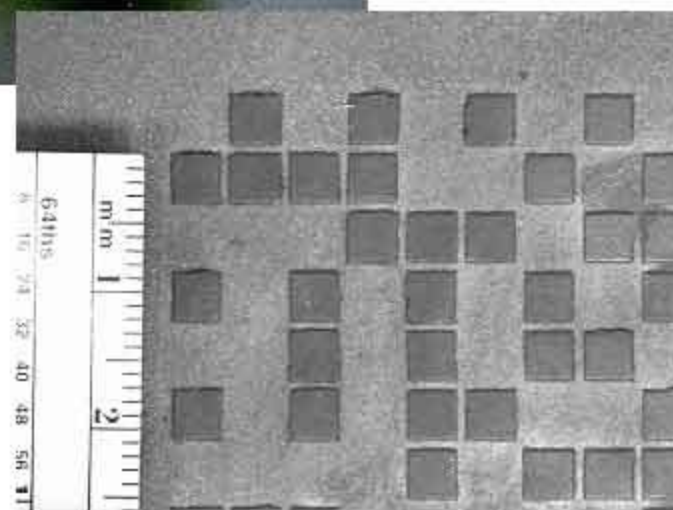
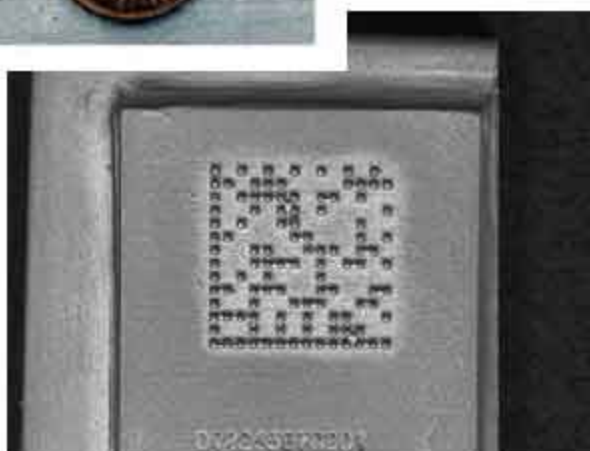
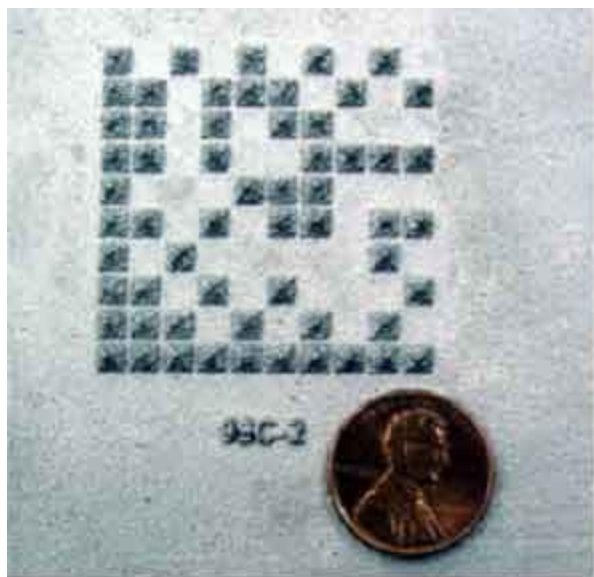
- Fluorescent Magnetic Particle Inspect per ASTM E1444
- Paint per MIL-STD-7179 (Primer per MIL-P-85582 Type I, Class 2: Top Coats per MIL-C-85285, Type I)
- Paint Strip per MIL-STD-871 (T.O. 4S-1-182)
- Temper Etch per MIL-STD-867
- Chrome Plate per MIL-STD-1501, Type II, Class 2, Thickness 0.001 INCH - 0.003 INCH
- Chrome Plate.Mask Marks
- Chrome Plate Strip per MIL-STD-871
- Nickel Plate per MIL-STD-868, Type II, Thickness 0.001INCH - 0.003 INCH
- Nickel Plate. Mask Marks
- Nickel Plate Strip per MIL-STD-871
- Flame Spray per MIL-STD-869, Type I, Thickness 0.025 INCH - 0.050 INCH
- Flame Spray.Mask Marks
- Flame Spray Strip per MIL-STD-871
- HVOF Coat, WC-Co 89-17, Thickness 0.004 INCH - 0.006 INCH
- HVOF Strip per MIL-STD-871
- Cadmium Plate per MIL-STD-870, Type II, Class 1, (Thickness 0.001 INCH)
- Cadmium Plate Strip per MIL-STD-871 (T.O. 4S-1-182, with Phosphoric Acid Dip)
- IVD Coat per MIL-DTL-83488, Type II, Class 1, (Thickness 0.001 INCH)
- IVD Strip per MIL-STD-871
- Electroless Nickel Plate per MIL-C-26074, Class 1, Grade A, (Thickness 0.001INCH)
- Electroless Nickel Plate Strip per MIL-STD-871



**Preliminary DoD tests reflect that new marking processes will survive servicing, repair and overhaul.**

**Most promising methods are:**

- Deep Dot Peening
- Deep Laser Engraving
- GALE
- Investment Casting
- LISI
- Micro-Milling
- Sand Casting







## Task 6 - Develop And Test Mobile Markers - 1st Unit Completed, 2<sup>nd</sup> and 3<sup>rd</sup> Units In Manufacturing

- Common User Friendly Software
- Electro-Chemical Etch
- Hand-Held and Fixed Dot Peen
- Micro-Milling
- Hand-Held and Fixed Lasers
- Stencil Generation
- Labels
- On Board Symbol Reading and Verification







## Task 7 - Develop And Test Mark Enhancement Kits - Complete

Contains shall include but not be limited to:

- Cleaning cloths
- DoD approved surface cleaning agents
- Surface scuffing materials, e.g., scotchbrite pads
- Electrolysis type cleaning system to remove oxidation layers
- Light and dark colored backfill media
- Protective clear coats (MIL-HDBK-132)
- Corrosion inhibitors
- Instructions to outline the process and requirements for removing contaminants, oxide films, heat induced discoloration, corrosion products and foreign contamination from metallic and non-metal surfaces

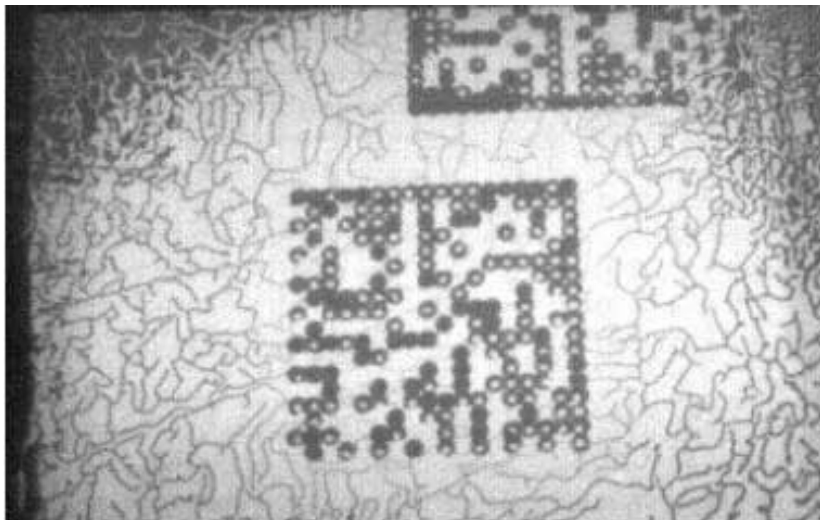




## Task 8 - Test Read-Through-Paint (RTP) Readers - 95% Complete

Magneto-optic markings have been applied to operational aircraft in the field and are being flight tested.





## First Operational Magneto-Optic Imagers Being Utilized In Read-Through-Paint Trials



## **Task 9 - Update Marking Standards - 95% Complete**

NASA Standard being revised on a real time basis and will be distributed to other appropriate standards groups when done

- DoD LOG AIT Office - Dan Kimball, Joint Interoperability and Standardization, Tel: (703) 767- 1598
- Fed Ex - Butch Ford (Chairperson of Permanent Bar Code Task Force under ATA),  
ATA SPEC2000, Tel. (901) 224-4465
- USAF - Brad Sanders, MIL-STD-130, Tel.: (937) 904-0789
- ISO - Matthew Williams, ISO TC 20, ISO/IEC WD 15415.8 (pending) & ISO/IEC WD 15426-2 (Pending), Tel. (202) 371-8443
- IAQG -Dale K Gordon, IAQG-9132 (pending), Tel. 317-230-3592





TABLE IV. Ground, Sub-orbital and Low Earth Orbit Environments

Marking Process	Part Environments										
	Ground and Sub-Orbital Operations										Low Earth Orbit Operations
	Abrasion	Chemicals - Deicer	Chemicals- Fuels	Chemicals- Grease	Chemicals- Hydraulic Fluid	Chemicals- Lubricating Oil	Foreign Object Damage (minor)	High Heat (Engines) + 2000F	Temperature: -30F to 140F	Ultra-Violet	Salt Cryst
Cast and Forge	X	X	X	X	X	X	X		X	X	X
Dot Peen	X	X	X	X	X	X	X		R	X	X
Electro-Chem. Coloring		X	X	X	X	X	X			X	X
Electro-Chem. Etch With Color Added*											
Forge	X	X	X	X	X	X	X		X	X	X
Ink Jet*				X							
Laser Bonding		X	X	X	X	X	X		X	X	X
LENS		X		X							
Laser-Coloring				X							
Laser-Engraving (Direct)	X	X	X	X	X	X	X	R	X	X	X
Laser-Engraving (Coat & Remove) *				X							
Laser-Etch (Coat and Mark)				X							
Laser-Etch (Direct)	X	X	X	X	X	X	X		X	X	X
Laser-Etch (Gas Assisted)				X							
Laser-Induced Surface Improvement		X	X	X	X	X	X		X	X	X
Laser-Induced Vapor Deposition											
Laser Shot Peen		X	X	X	X	X			X	X	X
Mechanical Engraving	X	X	X	X	X	X	X	X	X	X	X
Silk Screen*											
Stencil-Chemical Coloring											
Stencil-Ink*											
Stencil-Thermal Spray		X	X	X	X	X			X		

TABLE V. Service, Repair and Overhaul Environments

Marking Process	Part Environments															
	Service & Repair								Overhaul							
	Acid Etch	Alkaline Clean	Debrass Wash	Emission cleaning	Mechanical Abrasion Cleaning	Solvent Wash	Steam Cleaning	Ultra-Sonic Cleaning	Vapor Degreasing	Penetrant Inspection	Abrasive Blast - Plastic	Abrasive Blast - Glass	Abrasive Blast - Al/Or	Abrasive Blast - Grit	Acid Dip	Flame Spray
Cast or Forge	X	X	X	X	X	X	X	X	X							
Dot Peen	X	X	X	X	X	X	X	X	X							
Electro-Chem. Coloring																
Electro-Chem. Etch																
Engraving	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Forge	X	X	X	X	X	X	X	X	X							
Ink Jet*																
Laser Bonding																
LENS																
Laser-Coloring	X	X	X	X	X	X	X	X	X							
Laser-Engraving (Direct)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Laser-Engraving (Coat & Remove)																
Laser-Etch (Coat and Mark)																
Laser-Etch (Direct)	X	X			X	X	X	X	X							
Laser-Etch (Gas Assisted)																
Laser-Induced Surface Improvement	X	X	X	X	X	X	X	X	X							
Laser-Induced Vapor Deposition																
Laser Shot Peen																
Silk Screen*																
Stencil-Ink*																
Stencil-Thermal Spray																

Marking Tables being developed to list marking methods by use environment



## Summary

- NCMS Program is progressing with minimal issues
- All program requirements expected to be successfully meet.





# Next Major DPM Development Program



## Phase III USCG DPM Development Program

- Apply UID markings to all safety critical aircraft
- Demonstrate techniques and procedures for marking parts in the logistics warehouse
- Test new marking and c







# USCG 2-D Technology Demonstrations

Being held June 23rd (reception) and 24<sup>th</sup> (speakers and demonstrations) at the Aircraft Repair and Service Center (ARSC) Elizabeth City, NC. Contact Terry Boyce for clearance, Telephone (252) 335-6508  
2-D related technologies and Information to be featured:

- Body Worn Computer Systems
- Data Communications
- Strain/Fatigue Measurement
- Optical Reading Devices
- Mark Authentication System
- Marking Degradation Test Data
- Mark Restoration Kit
- Mark Quality Verification
- Mobile Marking
- NCMS Environmental Test Data
- New Marking Processes
- Sensor Reading
- Weight Measurement System



# UID Website

Developed by RVSI to provide additional UID information and support.  
Provides:

- Links to requirements
- Information related to UID development programs
- Implementation support services
- Lists of marking, verification, reading and communication contractors
- Marking and reading starter kits
- On-line training

[WWW.UIDSUPPORT.COM](http://WWW.UIDSUPPORT.COM)



## Questions & Answers



The Symbology Research Center is the most advanced 2-D symbology R&D laboratory in the world, maintaining the countries most comprehensive materials marking database. The center maintains a close relationship with NASA to further develop this 2-D technology. The SRC, through RVSI, holds more than a hundred patents related to 2-D and 3-D technology and has developed, enhanced and tested over 40 compressed symbology-marking methods. Our consulting service can usually solve your most difficult machine-readable part marking or code reading problems via the use of the Data Matrix symbology. Any government or commercial entity can request assistance on a specific product identification problem by submitting a Problem Statement through the Marshall Space Flight Center Technology Utilization Office or directly through the SRC.



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